

## ALUMINUM HOLLOW BENT MEMBER AND VEHICULAR MEMBER CONSTRUCTION

### BACKGROUND OF THE INVENTION

5 The present invention relates to an aluminum hollow bent member which is formed by cutting an aluminum straight hollow member into a predetermined length, followed by bending the same. The present invention further relates to a vehicular member construction using the thus obtained aluminum hollow bent member.

10 Japanese Utility Model Second Publication No. 6(1994)-029049 describes a vehicular member construction using a pair of tubular members which extend substantially in a fore-and-aft direction of a vehicle.

Moreover, Japanese Patent Unexamined Publication No. 11(1999)-293375 describes a vehicular member made of aluminum effective for reducing weight.

15 There may occur occasions requiring discontinuance of use of reinforcing plates so as to reduce the number of component parts as well as production steps. For such occasions, tubular members that constitute part of the vehicular member are to be increased in plate thickness and diameter. However, such increase may cause problems, for instance, increase in weight and cost. Moreover, the increase in diameter of the tubular member will cause interference with other component parts, 20 to thereby restrict layout.

### SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an aluminum hollow bent member which has features such as; bend rigidity and torsional rigidity obtainable without increasing the external diameter of the aluminum hollow bent member, reduced weight and cost, and eliminating need for a reinforcing plate when the aluminum hollow bent member is used as a side member.

It is another object of the present invention to provide a vehicular member construction having features such as those described above in terms of the aluminum hollow bent member.

30 There is provided a metallic product. This metallic product comprises a metallic curved hollow member having a hollow cross section which comprises a thin wall portion and a thick wall portion which is thicker than the thin wall portion. The metallic curved hollow member is produced by bending a metallic straight

hollow member produced by extrusion of aluminum material which is one of aluminum and aluminum alloy.

There is also provided a metallic product. This metallic product comprises a metallic curved hollow member having a hollow cross section which comprises a cross-shaped portion. The metallic curved hollow member is produced by bending a metallic straight hollow member produced by extrusion of aluminum material which is one of aluminum and aluminum alloy.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is an explanatory plan view of a vehicular member construction using a side member 10, according to a first preferred embodiment of the present invention.;

Fig. 2 is a cross section of side member 10 before a hydraulic forming, in other words, a cross section of a straight hollow member 1;

Fig. 3 is a view taken along lines A-A in Fig. 1, which is a cross section of a mounting portion for mounting a first suspension link bracket 13 to side member 10;

Fig. 4 is a view taken along lines B-B in Fig. 1, which a cross section of a mounting portion for mounting a second suspension link bracket 14 to side member 10.

Fig. 5 is a schematic showing directions of bend and torsional forces applied to side member 10. X-axis is disposed in a long side direction of side member 10, Y-axis is disposed in a longitudinal direction of side member 10, and Z-axis is disposed in a short side direction of side member 10. RX is a torsional direction around X-axis, RY is a torsional direction around Y-axis, and RZ is a torsional direction around Z-axis.

Fig. 6 is an explanatory perspective view showing improvement in bend rigidity and torsional rigidity attributable to a partially thick wall portion 10a on the periphery of side member 10, in which,

Fig. 6(a) shows thick wall portion 10a on a left side,

Fig. 6(b) shows thick wall portion 10a on an upper side,

Fig. 6(c) shows thick wall portion 10a on a right side, and

Fig. 6(d) shows thick wall portion 10a on both the left and upper sides;

Fig. 7 is a cross section of a side member 20 before the hydraulic forming, in other words, a cross section of a straight hollow member 7, according to a second preferred embodiment of the present invention;

Fig. 8 is a cross section of a mounting portion for mounting a first suspension link bracket 13 to side member 20;

Fig. 9 is a cross section of a mounting portion for mounting a second suspension link bracket 14 to side member 20;

5 Fig. 10 is a schematic cross section for explaining the hydraulic forming method;

Fig. 11 is a cross section of a side member 30 before the hydraulic forming, in other words, a cross section of a straight hollow member 2, according to a third preferred embodiment of the present invention;

10 Fig. 12 is a cross section of a mounting portion for mounting a first suspension link bracket 13 to side member 30;

Fig. 13 is a cross section of a mounting portion for mounting a second suspension link bracket 14 to side member 30;

15 Fig. 14 is a cross section of side member 40 before the hydraulic forming, in other words, a cross section of a straight hollow member 4, according to a fourth preferred embodiment of the present invention;

Fig. 15 is a cross section of a mounting portion for mounting a first suspension link bracket 13 to side member 40;

20 Fig. 16 is a cross section of a mounting portion for mounting a second suspension link bracket 14 to side member 40;

Fig. 17 is a cross section of an electric resistance weld tube; and

Fig. 18 is a perspective schematic view showing a vehicular member construction, according to a related art.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

25 Fig. 1 shows a vehicular member construction having a pair of side members 10 and 10, a first cross member 11, and a second cross member 12. Each of side members 10 and 10 extends substantially in a fore-and-aft direction of a vehicle. Moreover, the pair of side members 10 and 10 are spaced apart from each other in a widthwise direction of the vehicle. First and second cross members 11 and 12 30 connect the pair of side members 10 and 10. First and second cross members 11 and 12 are spaced apart from each other substantially in the fore-and-aft direction of the vehicle. Each of first and second ends of first cross member 11 is coupled with one of side members 10 and 10 at a first coupling portion. On an opposite side of the first

coupling portion of side member 10 (outside side member 10), there is provided a first suspension link bracket 13. Each of first and second ends of second cross member 12 is coupled with one of side members 10 and 10 at a second coupling portion. On an opposite side of the second coupling portion of the side member 10  
5 (outside side member 10), there is provided a second suspension link bracket 14. Each of first and second suspension link brackets 13 and 14 supports a suspension link (not shown) that links side member 10 and a wheel.

There is provided the aluminum hollow bent member and the vehicular member construction, according to first, second, third and fourth preferred  
10 embodiments of the present invention. In each of the preferred embodiments, it is a side member of the vehicular member construction that is exemplified for the aluminum hollow bent member.

Fig. 2 is a cross section of a straight hollow member 1, namely, a vehicular side member 10 before a hydraulic forming, according to the first preferred  
15 embodiment of the present invention.

An extruded aluminum alloy is cut into a predetermined length, to thereby form straight hollow member 1. The thus obtained straight hollow member 1 has a circular cross section. An inner circle is deviated rightward by  $\alpha$  in Fig. 2, to thereby form an eccentric pipe. Thus, in Fig. 2, a left thickness T2 is greater than a right thickness T1. Moreover, a section modulus is secured that is required for side member 10. Then, through the hydraulic forming (known), straight hollow member 1 (as a material) is bent, and the cross section of straight hollow member 1 is so swelled radially outwardly as to become rectangular, to thereby form side member 10 that has a partially thick wall portion 10a on its periphery. As is seen in Fig. 3,  
20 thick wall portion 10a of side member 10 mounts first suspension link bracket 13. Also, as is seen in Fig. 4, thick wall portion 10a mounts second suspension link bracket 14. First and second suspension link brackets 13 and 14 work to increase rigidity of the overall vehicular member construction.

Various kinds of known hydraulic forming methods can be applied such as the  
30 one shown in a related art, Japanese Patent Unexamined Publication No. 2000-246361 (P2000-246361A). Using the related art, straight hollow member 1 having the circular cross section is so bent as to correspond to a curved configuration of side member 10. Then, the thus obtained workpiece is pressed by means of a press and

the like, to thereby form a substantially rectangular cross section (preform). Then, the pressed workpiece is loaded into a cavity of upper and lower dies forming a rectangular cross section. The workpiece is then clamped by means of the upper and lower dies. Then, a liquid is injected into the pressed workpiece so as to cause a high 5 internal pressure. With this, the pressed workpiece is swelled radially outwardly along a die surface, to thereby obtain side member 10 having a rectangular cross section.

Thus obtained side member 10 has thick wall portion 10a that is partially thick on the periphery of the side member 10. Therefore, increase can be more restricted in 10 weight and material cost of the side member 10, as compared with increase in weight and material cost of another side member that has an equally thick wall portion on the entire periphery of the another side member.

Moreover, straight hollow member 1 before the hydraulic forming uses the 15 extruded material that is formed with a partially thick wall portion. The thick wall portion is partially thick in the circumferential direction. Therefore, the cost of straight hollow member 1 can be more reduced, as compared with the one that is formed from the electric resistance weld tube having an equally thick wall portion on the entire periphery of the electric resistance weld tube.

Furthermore, with thick wall portion 10a disposed partially on the periphery of 20 side member 10, a section modulus is secured that is required for side member 10 after the hydraulic forming. Therefore, side member 10 is allowed to obtain required bend rigidity and torsional rigidity, eliminating need for increasing an external diameter. Also, first and second reinforcing plates F1 and F2 (see chain lines in Fig. 25 1) are not needed any more. First reinforcing plate F1 was conventionally needed for reinforcing the connection for connecting first and second cross members 11 and 12 with the side member 10, while second reinforcing plate F2 was conventionally needed for reinforcing the mounting portion for mounting first and second suspension link brackets 13 and 14 to the side member 10.

Table 1 is a result of investigation in terms of bend rigidity and torsional 30 rigidity of side member 10 according to the present invention, as compared with a side member of a related art. The side member of the related art is the one that is formed from the electric resistance weld tube. The hydraulic forming is also carried

out on the electric resistance weld tube. The side member of the related art has an equally thin wall portion 10b on the entire periphery thereof.

In Table 1, the term "Improved" means that the bend rigidity or the torsional rigidity of the present invention has been improved compared with the side member of the related art.

[Table 1]

		Fig. 6			
		(a)	(b)	(c)	(d)
Bend rigidity	X	Improved	Improved	Improved	Improved
	Y	-----	-----	-----	-----
	Z	Improved	Improved	Improved	Improved
Torsional rigidity	RX	Improved	Improved	Improved	Improved
	RY	Improved	Improved	Improved	Improved
	RZ	Improved	Improved	Improved	Improved

Table 1 shows that the bend rigidity along X-axis and Z-axis, and the torsional rigidity around RX, RY and RZ have been improved as compared with the side member of the related art, irrespective of where thick wall portion 10a is formed.

Fig. 7 is a cross section of a straight hollow member 7 of a vehicular side member 20 before the hydraulic forming, according to the second preferred embodiment of the present invention.

An extruded aluminum alloy is cut into a predetermined length, to thereby form straight hollow member 7. Thus obtained straight hollow member 7 is a pipe which has a cross section formed with concentric inner and outer circles, with an equal wall thickness around the entire circumference of the straight hollow member 7. Moreover, a section modulus is secured that is required for side member 20 after the hydraulic forming.

Then, straight hollow member 7 (as a material) is bent through the hydraulic forming (known). The cross section of straight hollow member 7 is so swelled radially outwardly as to become rectangular in shape.

According to the second preferred embodiment, like the first preferred embodiment, the hydraulic forming has the following steps: Straight hollow member 7 having the circular cross section is so bent as to correspond to a curved configuration of the side member 20. Then, the thus bent workpiece is pressed by

means of the press and the like, to thereby form a substantially rectangular cross section (perform). Then, the pressed workpiece is loaded into a cavity of upper and lower dies forming a rectangular cross section. Then, the workpiece is to be clamped by means of the upper and lower dies. It is necessary to provide a difference in plate thickness of side member 20. Therefore, as is seen in Fig. 10, when a pressed workpiece 21 is loaded into the cavity of upper and lower dies 22, there is defined a gap 23 between die 22 and workpiece 21. The gap 23 is comparatively large so as to be provided for a thin plate. Then, a liquid is injected into pressed workpiece 21 so as to cause a high internal pressure. Then, pressed workpiece 21 on a side of gap 23 becomes greatly swollen so as to form a thin wall portion. The opposite side of the thin wall portion is formed with a partially thick wall portion 20a, to thereby form side member 20.

Thus obtained side member 20 is then mounted on first and second suspension link brackets 13 and 14, as is seen, respectively, in Fig. 8 and Fig. 9. Thereby, 15 rigidity of the entire vehicular member construction is improved.

Operation and effect according to the second preferred embodiment are omitted since they are substantially the same as those according to the first preferred embodiment.

Fig. 11 is a cross section of a straight hollow member 2 of a vehicular side member 30 before the hydraulic forming, according to the third preferred embodiment of the present invention.

An extruded aluminum alloy is cut into a predetermined length, to thereby form straight hollow member 2. Thus obtained straight hollow member 2 has four projections 3. Each of four projections 3 extends along an axial direction of a pipe 25 which has a cross section formed with concentric inner and outer circles. Four projections 3 are disposed circumferentially at regular angular intervals of ninety degrees. Thereby, straight hollow member 2 has partially thick wall portions in the circumferential direction. Moreover, a section modulus is secured that is required for side member 30 after the hydraulic forming. Then, straight hollow member 2 (as a 30 material) is bent through the hydraulic forming in a manner same as the one according to the first preferred embodiment. Then, the cross section of straight hollow member 2 is so swelled radially outwardly as to become rectangular, to thereby form side member 30 having a substantially rectangular cross section. Side

member 30 is partially formed with four thick wall portions 30a disposed at substantially equal intervals along the rectangle. As is seen in Fig. 12, thick wall portion 30a of side member 30 mounts first suspension link bracket 13. Also, as is seen in Fig. 13, thick wall portion 30a mounts second suspension link bracket 14.

5 Side member 30 having the thus obtained construction is partially formed with four thick wall portions 30a at substantially equal intervals. Thereby, rigidity of the entire vehicular member construction is improved.

10 Operation and effect according to the third preferred embodiment are omitted since they are substantially the same as those according to the first preferred embodiment.

Fig. 14 is a cross section of a straight hollow member 4 of a vehicular side member 40 before the hydraulic forming, according to the fourth preferred embodiment of the present invention.

15 An extruded aluminum alloy is cut into a predetermined length, to thereby form straight hollow member 4. Thus obtained straight hollow member 4 has a cross section formed with concentric inner and outer circles. On the inner circle (or actually an inner cylinder of straight hollow member 4), there is provided an intersecting portion 5 which is pictographically shaped into the plus sign "+" and is so disposed as to close the cross section of straight hollow member 4. In other words, 20 straight hollow member 4 has a cavity which extends in a longitudinal direction of straight hollow member 4 and is separated into four sub-cavities by intersecting portion 5. Moreover, a section modulus is secured that is required for side member 40 after the hydraulic forming.

25 Then, straight hollow member 4 (as a material) is bent through the hydraulic forming in the manner same as the one according to the first preferred embodiment. Then, the cross section of straight hollow member 4 is so swelled radially outwardly as to become rectangular, to thereby form side member 40 that is formed with intersecting portion 5. As is seen in Fig. 15, intersecting portion 5 of side member 40 mounts first suspension link bracket 13. Also, as is seen in Fig. 16, intersecting portion 5 mounts second suspension link bracket 14. Thereby, rigidity of the entire vehicular member construction is improved.

Side member 40 having the thus obtained construction is formed with intersecting portion 5 on the inner surface of side member 40. The intersecting

portion 5 closes the cross section of side member 40. Thereby, required bend rigidity and torsional rigidity can be obtained even if the external diameter is small.

Other operation and effect according to the fourth preferred embodiment are omitted since they are substantially the same as those according to the third preferred embodiment.

The entire contents of Japanese Patent Application No. 2000-112573 (filed April 13, 2000) is incorporated herein by reference.

Although the invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiments described above. Modifications and variations of the embodiments described above will occur to those skilled in the art, in light of the above teachings.

For example, it is the straight hollow member having the circular external cross section that has been used according to each of the embodiments described above.

However, the present invention is not limited to the circular external cross section.

For example, a straight hollow member having a rectangular external cross section can be used under the present invention.

Moreover for example, it is the hydraulic forming method that is used for obtaining the side member from the straight hollow member, according to each of the embodiments described above. However, the present invention is not limited to the hydraulic forming method that brings about an excellent shape stability of workpieces. For example, a press can be used for bending the straight hollow member so as to obtain the side member, provided that the straight hollow member is partially thickened circumferentially and has a cross section rectangular in shape.

Furthermore for example, it is the side member that is embodied according to each of the embodiments described above. However, the present invention is not limited to the side member. The present invention is also applicable to the cross member.

The scope of the invention is defined with reference to the following claims.